DECEMBER 2002 HIGHLIGHTS OF THE PULSED POWER INERTIAL CONFINEMENT FUSION PROGRAM

Progress in Pulsed Power Design for the Refurbishment of Sandia's Z Accelerator

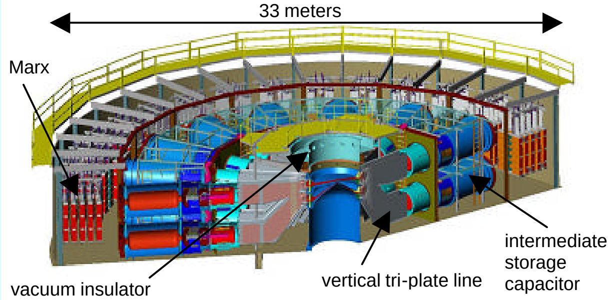

Fig. Schematic showing some of the ZR components.

Work is proceeding on the design and testing of key systems for the refurbishment of Z, which is scheduled to be complete in 2006. Z, which converts stored electrical energy into short (sub-microsecond), high-power electrical pulses, began operating in December 1985 in a light ion configuration. Since October 1996, Z has operated in a z-pinch configuration to provide experimental data to the Stockpile Stewardship Program of the National Nuclear Security Administration (NNSA). Refurbishment of Z will extend the lifetime of its components and improve its performance, reliability, and shot rate. NNSA's Required Technical Base and Facilities Program is funding the Z Refurbishment (ZR) Project. Our progress on these activities is described below.

ZR (see figure) will use 60-stage Marx generators—devices that store electrical energy somewhat like batteries, with a new capacitor design that allows twice the energy of the present Z. Vendor-supplied prototypes of the capacitors are the subject of an intense qualification and life-test program, using an automated capacitor test system. The capacitor order for the prototype Marxes (140 units) will be placed in January. The full order (~2400 units) will be placed shortly thereafter. After the acceptable capacitors are delivered, the same test system will spot-check them before installation on the Marxes.

We completed conceptual design of intermediate storage capacitors for ZR that store the Marx energy before it is delivered downstream by 36 laser-triggered gas switches. Unlike on Z, these capacitors will use a deionized water system separate from the main pulse-forming system tank to relax the water quality requirements in the main tank. The laser-triggered switches, which synchronize the 36 pulse-forming lines, are being tested for lifetime and reliability on the Switch Test Bed Facility. The original Z triggering system used a single 4-joule laser for all 36 switches. On ZR, a separate laser will trigger each switch, allowing greater flexibility to deliver the shaped current (and therefore pressure) pulses the Dynamic Materials Properties Campaign requires to obtain high-pressure data. On ZR, water-insulated vertical *tri-plate* transmission lines will transport the energy from the pulse-forming lines to the vacuum interface. This geometry uses space more efficiently than the present Z *bi-plate* lines, and the vertical orientation is more conducive to removing air bubbles in the water than the present horizontal orientation. The tri-plate lines also eliminate coupling among the four pulse-forming levels in the water section; elimination of this coupling raises the efficiency of producing the desired shaped pulses.

On the Advanced Pulsed Power Research Module (APPRM), we are testing both the timing jitter and losses in the water switches and the power flow in the pulse forming lines. The increased power requirement of ZR raises the voltage and current at which the water switches must function. We have not studied this regime extensively before, although experiments on PITHON, a Defense Threat Reduction Agency facility, have demonstrated the feasibility of the water switch design. Water switch tests at 4.2 megavolts on the APPRM indicate the current delivered to the center of ZR will not be substantially reduced, based on more than 100 full-voltage/full-current experiments. An important part of the design effort for ZR is to understand the energy losses that can occur in the low-impedance pulse forming lines. Geometric transitions in this part of ZR can introduce high-order power flow modes--that is, modes that are not transverse electromagnetic (TEM) modes--into the transmission lines. We are developing analytic and computational models of the pulse forming lines to study the power flow to the vacuum interface and thereby minimize the generation of non-TEM modes that cause energy loss.

With new cleaning and preparation techniques, we have approximately doubled the voltage the vacuum insulator stack can tolerate. The vacuum insulator has traditionally been one of the weak links in the power-flow chain. Successful application of these cleaning techniques to large facilities would allow closer matching of the stresses of the water transmission lines and the vacuum interface, which would save space and reduce the overall Project cost.

For more information on this article contact: Mark Savage, mesavag@sandia.gov; or SNL ICF Manager: Keith Matzen, mkmatze@sandia.gov.
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